BRUCELLOSIS OF CATTLE

(BANG'S DISEASE, INFECTIOUS ABORTION)

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BRUCELLOSIS of cattle, also known as Bang's disease and infectious abortion, is widely distributed and results in serious losses to the livestock industry. It is caused by the germ, *Brucella abortus*. The disease is commonly introduced into healthy herds by the addition of infected cows or infected pregnant heifers.

The act of abortion is its best-known symptom. Other symptoms are weak, though living calves; retained afterbirths; and sterility.

The germs may be in the uterus or the udder, and in certain lymph glands and joints of cows, and in the generative organs of bulls.

Aborting cows may eliminate the germs in the afterbirth, in uterine discharges for limited periods, and in the milk for prolonged periods.

The malady appears to be commonly acquired through the mouth in feed and drink contaminated with the germs, by licking affected animals to which the germs adhere, contaminated mangers, or other objects. The skin and the membranes which line the eyelids may also provide a means of access for the abortion germ into the animal. Proof that bulls transmit the disease through the act of service is lacking.

There is no factual basis for believing that abortion losses can be prevented or reduced by the administration of drugs or medicinal compounds.

The disease may be controlled in several ways, the method of preference depending upon herd conditions and the severity and extent of the disease in the herd.

This bulletin is a revision of and supersedes Farmers' Bulletin 790, Contagious Abortion of Cattle; Farmers' Bulletin 1536, Infectious Abortion of Cattle; and Farmers' Bulletin 1704, Bang's Disease (Infectious Abortion).

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BRUCELLOSIS OF CATTLE[1]

(BANG'S DISEASE, INFECTIOUS ABORTION)

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Contents

IMPORTANCE OF THE DISEASE

BRUCELLOSIS of cattle, also called Bang's disease and infectious abortion of cattle, is an infectious, usually chronic, disease. The name, brucellosis, is preferred by scientific authorities because it is derived from that of the organism, *Brucella abortus*, which causes the disease. The principal manifestation of brucellosis is the premature expulsion of the calf or fetus. In addition to the loss of the calf, the act of abortion in a milking cow results in breaking up the normal lactation period and consequently in a diminution of the quantity of milk produced. Affected cows often suffer from retained afterbirth, are difficult breeders, and sometimes become sterile. Surveys made in 1935 indicated that approximately 10 percent of the cattle of the United States were affected with brucellosis and that the disease was prevalent in all parts of the country. The tremendous loss incurred by the livestock industry as a result of *Brucella* infection is thus apparent.

In the 40 years brucellosis of cattle has been investigated in this and other countries, most of the essential factors in connection with the nature of the disease have been established. Methods of control have also been established, but unfortunately none of these are easy of operation or inexpensive. As a result, very little was actually accomplished in this line until 1934, when the United States Department of Agriculture, in cooperation with several of the States, inaugurated a control program based on the test-and-slaughter method of eradication. In those States in which this method has been in operation, the extent of infection has decreased markedly.

In addition to its effect on the livestock industry, brucellosis in cattle has a bearing on public health. The United States Public

[1] This is a revision of and supersedes Farmers' Bulletin 1704, Bang's Disease (Infectious Abortion) by John M. Buck, Animal Disease Station. Dr. Buck died in May 1937.

Health Service recognizes that the milk of cows containing *Brucella* organisms is capable at times of causing the disease in man, and that man may become infected during the care or treatment of aborting cows.

CAUSE OF THE DISEASE

As previously stated, brucellosis of cattle is caused by the micro-organism *Brucella abortus* (fig. 1). This organism was discovered in 1896 by Bernard Bang, a Danish investigator, and for some time was known as the Bang bacillus. Previously, in 1887, however, David Bruce, an English army surgeon, had recovered an organism from the blood of English soldiers affected with fever on the isle of Malta. This germ was traced to the milk of goats. In 1914, Jacob Traum, then an investigator in the United States Bureau of Animal Industry, recovered a similar organism from aborting swine. Alice Evans, now of the National Institute of Health, showed while a member of the scientific staff of the Bureau of Animal Industry that these three organisms were very closely related as to size, shape, type of colony growth on culture media, and the blood reactions produced in affected animals. All three of these micro-organisms were later given the generic name of *Brucella* in honor of the original discoverer, Bruce.

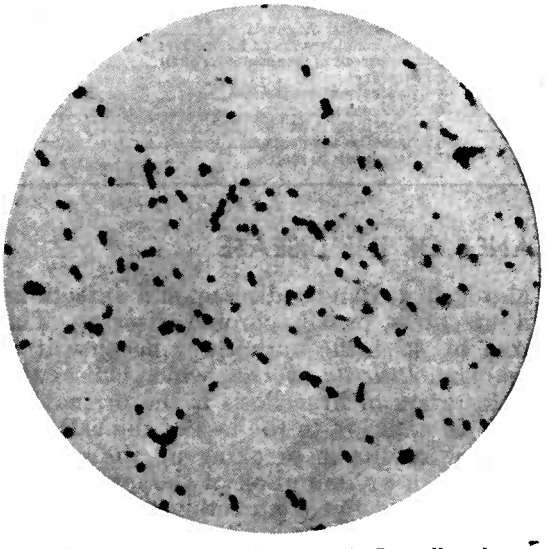

FIGURE 1.—Photomicrograph of *Brucella abortus*, the cause of brucellosis of cattle, or Bang's disease. Magnified 1,700 times.

The species found in cattle was termed *Brucella abortus;* the species in swine, *Brucella suis;* and the species in goats, *Brucella melitensis.* Under natural conditions of exposure, cattle become infected with *Br. abortus;* swine with *Br. suis;* and goats with *Br. melitensis.* Rare instances have been reported in which cross infection has occurred.

SUSCEPTIBILITY

The pregnant heifer and pregnant cow offer the means by which brucellosis is perpetuated. Calves and unbred heifers show a marked resistance to infection and the *Brucella* organisms, when they gain entrance to the bodies of such animals, are usually disposed of by the natural defensive mechanisms of the animal. In pregnant animals, however, for reasons not clearly understood, the placenta (the membranes covering the fetus) offers a medium very favorable to the the growth of the *Brucella* organism. Attaching the fetal membranes or placenta to the uterus are numbers of button-shaped

masses of tissue known as cotyledons. It is through these cotyledons that the blood of the dam carries oxygen and nutrients necessary to the growth of the fetus. *Brucella* organisms reach these cotyledons probably through the blood stream, grow there in large numbers, and eventually cause degeneration or necrosis of the cells, the final result being the premature expulsion of the fetus, or abortion. Thus, it is apparent that were it not for the fact that *Brucella* organisms have a predilection for the placental tissues of the cow and are able to grow there without resistance, brucellosis probably would not be perpetuated in cattle. Bulls are susceptible to brucellosis, the organism usually lodging in the testicles or the seminal vesicles.

Horses and mules readily develop a sensitivity to the agglutination test for brucellosis following contact with infected cattle and the organism, *Brucella abortus*, has been recovered from abscesses on the poll and withers of this species (poll evil and fistulous withers) and also from the urine and feces. On farms where there are herds of cattle in which difficulty is experienced in controlling the disease, it is advisable to apply the blood test to all equines.

Brucellosis in sheep has been reported in European countries as being caused by *Brucella abortus*, but from surveys made it would appear that the disease occurs only rarely in the United States.

Goats, swine, dogs, cats, and fowl are very resistant, as species, to experimental exposure to *Brucella abortus*, but the organism has been recovered occasionally from individual animals of each of these species where there has been close association with aborting cattle. Goats are the natural hosts of *Br. melitensis* and swine of *Br. suis*, which are distinct species of *Brucella* organisms and differ in some respects from *Br. abortus*, the cause of brucellosis of cattle or Bang's disease.

MODE OF INFECTION

The most common manner in which brucellosis is transmitted to a clean herd is through the introduction of infected animals. The disease may also be contracted by placing healthy cattle on a common pasture with infected cattle or by contact with infected cattle at livestock shows and sales. Birds and flies have been suggested from time to time as possible factors in the spread of this infection, but available data indicate that they play very little, if any, part in this connection. At the Bureau of Animal Industry's Animal Disease Station, Beltsville, Md., where brucellosis in cattle is studied, groups of infected and healthy cattle have been maintained for years on the same premises, but in separate fields, no protection being given the normal animals from birds and flies. No spread from diseased to normal cattle has resulted by these means. Experimentally, *Brucella* infection may be transmitted by depositing germs on the eyeball or on the abraded skin of pregnant cattle, but in these cases very large numbers of organisms are used, thousands of times more than would ordinarily be carried by flies, birds, or dogs.

It has been shown that horses placed with infected cattle develop the ability to react to the agglutination test for this disease. Data collected by C. P. Fitch, of the Minnesota Agricultural Experiment Station, indicate that more tests are required to eradicate brucellosis on farms where horses or mules show a reaction than on infected farms where equines show no reaction. *Brucella abortus* has been recovered

from many cases of poll evil and fistulous withers. In experiments made at the Animal Disease Station, where two horses affected with fistulous withers from which *Brucella abortus* was recovered were placed with six normal pregnant cattle, the disease was not spread from horses to cattle. It appears, therefore, that equines play only a minor part in the spread of this infection to cattle.

Infection in cattle is believed to take place mainly through the digestive tract. At the time of abortion, the afterbirth or placental membranes, the fluid in these membranes surrounding the fetus, and discharges which may persist for several weeks after the animal has aborted are teeming with virulent *Brucella* organisms. Thus, infective material may be spread on the pasture, yards, and barns, and, through the splashing of urine, organisms may be deposited on the skin of susceptible cows. A cow's tongue serves as its washcloth. A cow licks not only itself but other cows, and discharges from the uterus of an aborting cow may thus be ingested by other animals of the herd.

The skin as a portal of entry to *Brucella* organisms should not be overlooked. Cows may lie down on soil or bedding contaminated with the discharge of an aborting cow. Urine contaminated with the uterine discharge may be splashed on the skin of other cows, especially on the legs. Since wounds or abrasions of the skin are common, especially on the extremities, it is possible that infection may result in susceptible animals by the invasion of the organisms through the broken skin.

In the early days of the investigation of brucellosis in cattle, it was believed that the infected bull played a large part in the spread of the disease. Later investigation, however, showed that bulls affected in the testicles were poor breeders or even nonbreeders. Experiments were reported in a small number of animals in which virulent *Brucella* organisms were injected into the uterus immediately following service, but none of the cows so treated developed the disease. A few instances have been reported in which the evidence points strongly to the possibility of cows having become infected through service with a bull known to be infected in the genital organs. The evidence as a whole however, indicates that the bull plays, at best, only a minor role in the spread of infection through service. In any event, the infected bull is not only an unprofitable but also an undesirable animal and should not be kept in an otherwise clean herd.

PERIOD OF INCUBATION

The period of incubation of the disease, which is the time elapsing between exposure and the first indication of infection (abortion or the development of a titer in the blood to the agglutination test), is variable. It depends on the susceptibility of the animal, the amount of exposure, and the virulence of the infecting strain of *Brucella abortus*. This period is usually about 3 months, but under unusual conditions may vary from 6 weeks to 6 months. A few instances have been reported in which pregnant cows did not react to the agglutination test until a short time after they calved. It is obvious, therefore, that a bovine animal although negative to the agglutination test, when purchased, should not be placed with a negative herd until further tests over a period of several months, and in the case of a pregnant cow until she has calved, continue to show the animal to be negative.

The act of abortion due to *Brucella* infection may occur any time after the second month of pregnancy and depends on the susceptibility of the animal and the period during pregnancy when exposure occurs. When abortion occurs from late in the seventh to early in the ninth month, a living but weak calf may be expelled. Such calves are unthrifty and usually succumb to scours or other calfhood ailments. By far the greatest number of abortions occur during the fifth to seventh month, and it is in this group that retained afterbirth and breeding troubles most commonly occur.

When brucellosis gains entrance into a normal herd, the disease is in a very active state for a year or two. Evidence from both field and experimental studies shows that it requires a relatively large number of organisms to cause brucellosis in the majority of cattle, even though pregnant. In fact, under artificial exposure some cattle have withstood enormous numbers of virulent organisms and this undoubtedly accounts for the fact that even in a virgin herd it is rare that more than 50 percent of the animals contract the disease when it is in its most active stage.

The usual chain of events following exposure, as shown by experimental evidence, is as follows: The organisms enter the blood stream either through the digestive tract or the lymph channels of the skin and become localized temporarily in the various lymph nodes. In the nonpregnant animal, the disease seldom goes beyond this stage and the organisms are gradually eliminated from the body. In the pregnant animal, however, the organisms reach the uterus, attacking the fetal membranes and even enter the body of the fetus. *Brucella* organisms can usually be recovered from the stomach contents and lungs of the aborted fetus. With the localization of the organisms in the body, changes in the blood occur, one of which is the presence of a specific substance known as agglutinin. The quantity of agglutinating substance produced depends upon the activity or extent of the disease. This will be discussed more fully under diagnosis. Abortion or the birth of a weak calf is the usual result of the disease in the active stage. Following abortion, the uterus is more or less inflamed; the afterbirth may be retained, causing further irritation; and a discharge may persist until the uterine condition is cleared up. Coincident with the disease in the uterus, *Brucella* organisms may localize in the udder and it is in this organ that the infection tends to become more or less permanently established. It is unusual for the udder to become infected unless there is or has been infection in the uterus.

There are many variations from this procedure, however. When infection takes place late in pregnancy, a normal calf may be born although the uterus and udder may be infected. The infection may disappear from the uterus and localize only in the udder. The body and horns of the uterus and the Fallopian tubes may be thickened and the ovaries may become involved. Such animals become difficult breeders and if the changes in the uterus are extensive permanent sterility may result. Following abortion, some animals recover entirely from the infection and thereafter remain immune or greatly resistant to reinfection.

After the storm of abortion has passed, which may last about 2 years, the disease passes into the chronic stage. Most of the animals that contract the disease will become chronically infected in the udder. The udder infection may persist for several years and some-

times for the life of the animal. Some animals may continue to abort on succeeding pregnancies. Others may have a normal calf on the succeeding pregnancy and abort on the one following, but a majority of the chronically infected animals fail to continue to abort. This does not mean, however, that they are safe animals because the disease may be transferred to the uterus from the udder on succeeding pregnancies even though normal parturition occurs. The uterine discharge of such animals following calving may contain numbers of virulent *Brucella* organisms and thereby continue to be a source of exposure. In chronic infection in a herd, abortions are most often confined to additions to the herd and heifers during their first pregnancy following exposure.

It is well to bear in mind the difference between brucellosis in the active stage and the disease in its chronic form as this phenomenon is utilized by producers of so-called abortion cures in the sale of their products. If remedies or cures are used during the latter part of the active stage, the fact that abortions cease may be ascribed to the use of the medicine, by one not acquainted with the facts, whereas the apparent improvement is a natural occurrence.

SYMPTOMS

The symptoms that denote the presence of brucellosis are rather inconstant and indefinite. The act of abortion is probably the most widely known and most readily observed symptom (fig. 2), but it may easily be misinterpreted, since not all cows that abort are affected with the disease. The prompt recognition of the disease in affected herds, moreover, is rendered difficult because of the fact that many animals which acquire the disease never abort.

When the act of abortion occurs, it may be preceded by changes commonly observed in cows approaching normal parturition, such as enlargement of the udder, slight swelling of the external genitals, uneasiness, and straining. Also, discharges from the genital tract preceding the act may occasionally be observed. The fetus may be expelled during any stage of its development.

Fluid or semifluid materials are eliminated from the genital tracts of animals for a variable period following the act of abortion. The length of time that such discharges continue depends both on the severity of the disease in the uterus and the manner of treatment. The discharges are usually brownish or yellowish brown, but may not differ greatly in appearance from discharges in cases of retained afterbirth not caused by the abortion germ. The afterbirth, when expelled or removed and examined before becoming markedly putrefactive, almost always shows changes that aid the trained observer in recognizing abortion diseases.

Areas of the membrane that are normally thin and translucent may present a leathery appearance or be studded with small elevations, and the cotyledons (tumorlike enlargements, where union between dam and fetus is established), may be changed entirely or partially from a dull red to a yellowish brown or brownish color due to the destructive action of the invading *Brucella* organisms. The irregular surfaces of some of the cotyledons may likewise be occupied by a brownish cheese-like material. The absence of these changes, however, does not necessarily indicate that the abortion germ has not been active.

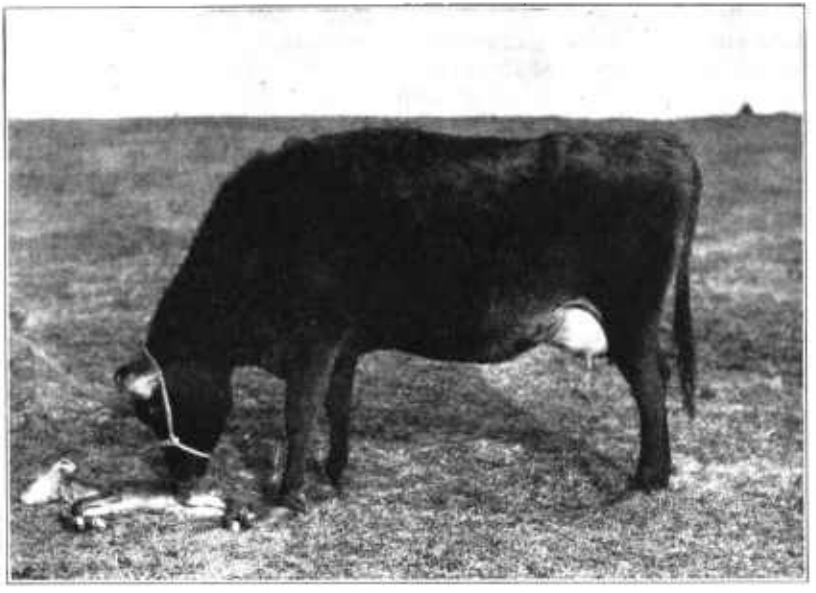

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FIGURE 2.—A cow with her dead fetus. This abortion occurred during the seventh month of pregnancy. Cattle of all breeds and degrees of breeding may be affected.

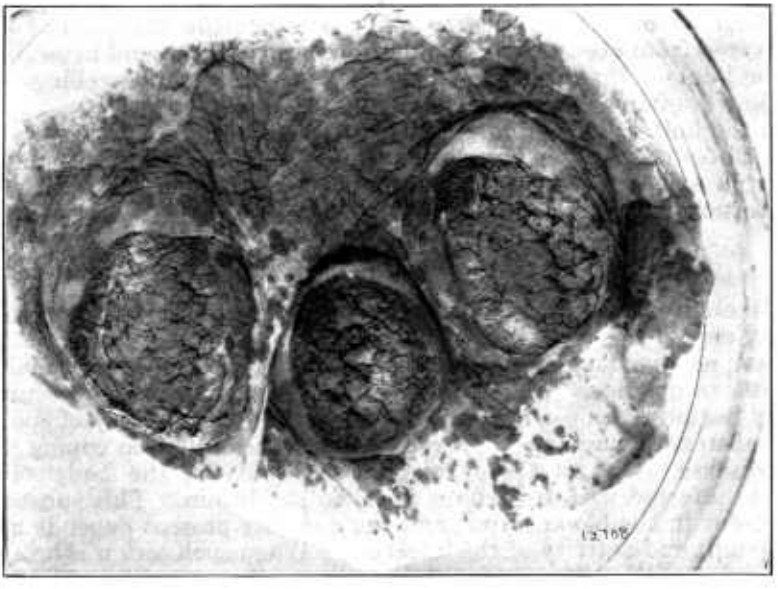

FIGURE 3.—A section of the placental membranes showing three cotyledons, or "buttons," extensively diseased as a result of infection with *Brucella abortus*. (Courtesy of C. P. Fitch, University of Minnesota.)

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Sterility (barrenness) is usually a troublesome factor in herds into which the disease has gained entrance. Although cows which have aborted may conceive at the first service, it is often necessary to breed an aborter repeatedly before conception takes place.

Because sterility frequently causes more or less trouble in herds free of abortion disease as well as in infected herds, it does not constitute definite evidence that *Brucella abortus* is involved. The retention of the afterbirth likewise does not definitely indicate the presence of the disease, as this condition may occur when brucellosis is absent.

Although none of the symptoms mentioned furnish definite knowledge as to the presence or absence of the malady, they may well be regarded with suspicion and as justifying prompt action. This applies particularly to the act of abortion. Until a definite diagnosis with the agglutination test can be made, it is advisable to infer that an aborting animal is affected with the disease and to proceed in accordance with that inference.

LESIONS OF BRUCELLOSIS IN CATTLE

Cattle affected with brucellosis have few lesions, or those pathological changes in the body tissues resulting from contact with *Brucella abortus*. In the cow, the principal and usually the only lesion found is in the uterus which may be thickened and inflamed. In the udder, although many *Brucella* organisms may be present, gross pathological changes are rare and when such changes do occur they are usually due to the simultaneous presence of other micro-organisms, such as streptococci.

Instances have been reported in which *Brucella abortus* has been recovered from abscesses in the lungs, liver, or spleen, and in swellings in the joints. Probably the most frequent site of joint swellings is in the knees, giving the latter a baggy appearance.

In the bull, lesions occur in the testicles and seminal vesicles. One or both testicles may be involved and the lesions may vary from slight to gross enlargement. In the latter event, the generative tissue of the testicle may be destroyed.

DIAGNOSIS

Although the act of abortion is the principal manifestation of brucellosis, it does not in itself constitute a positive diagnosis of the disease, as abortions may result from many other causes. In making a positive diagnosis, use is made of a phenomenon which occurs in many bacterial diseases, that of the production by the body of specific antisubstances which are believed to assist the animal in coping with the disease. One of these substances formed in the body of an animal infected with brucellosis is called agglutinin. This substance is present in the blood serum, and the quantity present depends upon the extent and activity of the infection. When such serum is brought in contact with a suspension of *Brucella* organisms called antigen, it will be noticed that the organisms are gathered together in clumps, or technically are agglutinated. This is the basis of the agglutination test.

The blood serum is the clear, straw-colored fluid in which the blood cells are suspended. To obtain the serum for test, a sterile needle is inserted through the disinfected skin into the jugular vein, the large

vein on either side of the animal's neck. About 5 cc. of blood are drawn into a sterile tube, and the tube is stoppered. Within a few minutes the blood coagulates, and within a few hours the serum gradually separates from the clot. The serum may then be withdrawn from the tube by means of a pipette..

There are two methods of making the agglutination test. One is called the tube or slow method, and the other the plate or rapid method. In setting up the tube test, five tubes are placed in a rack. Into each tube a constant quantity of antigen is placed, and a decreasing quantity of serum. In the first tube the proportion of serum to antigen is 1 to 25; in the second tube, 1 to 50; in the third, 1 to 100; and so

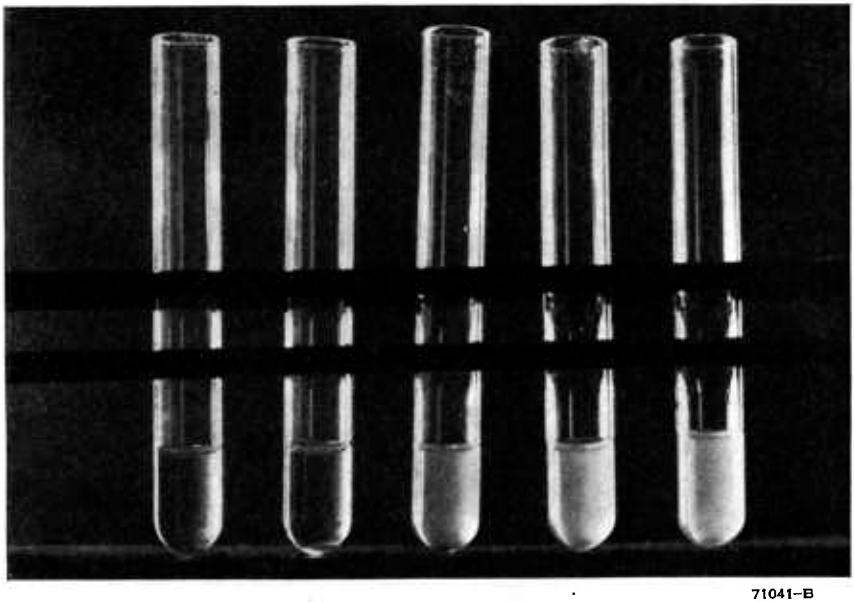

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FIGURE 4.—Tube agglutination test for diagnosis of brucellosis. The serum-antigen dilutions of these tubes, from left to right, are: 1:25, 1:50, 1:100, 1:200, and 1:400. The test shows a blood serum titer of 1:50 which is interpreted as suspicious.

on up to 1 to 400. The tubes are then incubated for 48 hours when readings are made. If the serum does not contain the agglutinin of Bang's disease, the appearance of the suspension in all tubes will remain unchanged. The presence of specific agglutinin in various quantities will be demonstrated in the individual tubes by clearing due to the clumping and settling of the antigen which may be seen in a thin layer at the bottom of the tube (fig. 4). The number of tubes so cleared constitutes the titer of the serum. Thus, if only the first tube shows agglutination, the titer is 1 to 25, and if the first and second tubes only are cleared, the titer is 1 to 50.

As a result of many years' experience with the agglutination test, the status of infection in any individual animal may be determined very accurately. Following infection, the titer of the blood usually increases, and if localization occurs, a positive titer, that is, 1 to 100 or

higher, develops. If the titer does not go beyond 1 to 50 in repeated tests, it usually indicates that the infection is not permanent and that the animal will eventually recover. In some laboratories, the 1 to 25 test is not made because it has been found that in instances there will be nonspecific agglutination at this dilution.

In the plate or rapid test, use is made of the same phenomenon. Four droplets of serum in decreasing amounts are placed on a clear glass plate with a capillary pipette, and on each droplet of serum is

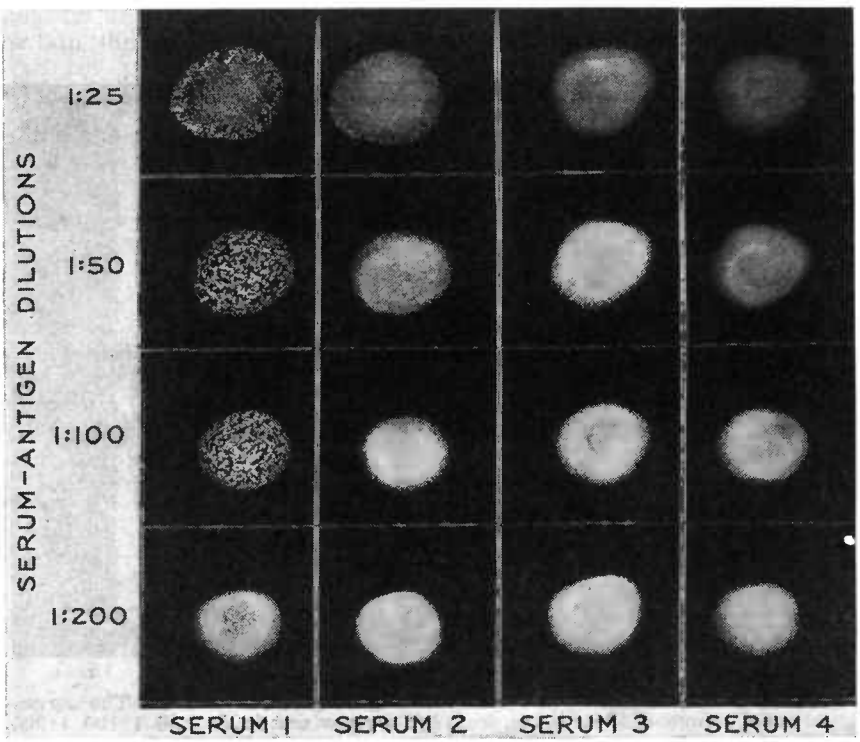

FIGURE 5.—Plate agglutination test of four bovine serums for diagnosis of brucellosis. Serum 1 shows complete agglutination in first three dilutions and incomplete at 1:200; diagnosis positive. Serum 2, complete agglutination in 1:25 and 1:50 dilutions and partial in 1:100; diagnosis very suspicious. Serum 3, agglutination at 1:25 dilution only and serum 4, negative in all dilutions; diagnosis negative.

placed a drop of a very dense suspension of *Brucella* organisms or antigen. These mixtures are spread into a thin, even layer over the glass plate (fig. 5). The proportion of serum to antigen is so adjusted that the results will correspond to the tube test. If no agglutinin is present in the serum, each of the areas will maintain its original appearance. If agglutinin is present, very shortly after the mixture is made the clumping of the organisms can be seen with the naked eye. This test is a valuable addition to the tube test and is useful in that the results of the test may be ascertained in 8 minutes, whereas the tube test takes 48 hours. The plate test, if the antigen is properly adjusted, is as efficient as the tube test.

Experiments have shown that after pregnant heifers were fed material infected with *Brucella abortus*, reactions in some cases were slow in developing. In some instances a period of between 3 and 4 months was required before a positive diagnosis by the agglutination test was established. It seems reasonable that when animals acquire the disease in the usual manner in infected herds, a like period may sometimes elapse before the fact is revealed by the test. A single negative test, consequently, cannot always be expected to give the owner of exposed animals definite assurance that they are not in the early stage of the disease.

Another method of testing for brucellosis is the complement-fixation method. This test likewise depends upon changes occurring in the blood following infection. The complement-fixation test is much more technical than the agglutination test, and since results with the former are no better than with the agglutination test, it is not extensively used.

Agglutinin may also be demonstrated in the whey or fluid portion of the milk of cows affected with brucellosis, especially if the disease occurs in the udder. It has been noted repeatedly that calves suckling affected dams may develop a titer to the agglutination test. After a calf is weaned, its titer is gradually lost. This ability to react is believed to be a passive rather than an active condition, as such calves when they grow older and become pregnant are usually susceptible to infection with *Brucella abortus*. The agglutinin of brucellosis is destroyed at temperatures above 160° F. but not at the usual pasteurizing temperature for milk, which is 145° F. for 30 minutes. It has been shown that the ingestion by calves of pasteurized milk returned from creameries may sometimes cause these calves to show a positive or partial agglutination reaction. However, a temperature of 145° F. for 30 minutes kills the *Brucella* organisms in such milk; and it is, therefore, safe for consumption by calves or other animals.

DEPENDABILITY OF THE AGGLUTINATION TEST

The agglutination test, like most other biological tests for the detection of disease, has its limitations. Its use is sometimes criticized because: (1) A single test does not allow a differentiation to be made between the different stages of infection in an animal; (2) on very rare occasions an animal may abort before a positive reaction to the test is obtained; and (3) low-titer reactions may sometimes result from causes other than Bang's disease. To one skilled in its interpretation, however, the agglutination test offers a very valuable and dependable means of diagnosing this disease and the degree of error in its practical application is very slight. The fact that thousands of herds have been freed from infection through its use is evidence of the dependability of this test.

DIFFERENTIAL DIAGNOSIS

Among the other causes of abortion in cattle are: Injuries, especially during shipment; acute diseases causing severe fever, such as anthrax, hemorrhagic septicemia, and streptococcic infection; and certain molds (*Aspergillus fumigatus*, *Absidia ramosa*, and a species of the genus *Mucor*). The avian tubercle bacillus has been reported as the cause of abortion in certain sections of Europe, but no record of such a case has been reported in the United States. Abortions have been reported due to nutritional deficiencies, that is, the lack of certain food

elements necessary to the development of the fetus. In range animals, following severe droughts, this condition is believed to be a cause of abortion. A micro-organism called *Vibrio foetus* has been recovered from aborted fetuses and afterbirths in a number of herds.

Another cause of abortion and sterility in cattle is a venereal disease known as trichomoniasis. It is caused by a microscopic parasite, *Trichomonas foetus*. This disease is spread by an infected bull during service. The organisms localize first in the vagina and later in the uterine cavity of the cow. Severe cases may result in an accumulation of pus in the uterus, or pyometra, difficult breeding, and sterility; and in pregnant animals abortion may occur. This disease was first reported in the United States in 1932 and is evidently spreading as it has since been reported in various sections of the country. Its relative importance has not yet been determined. Certain poisonous plants have been mentioned as probable causes of abortion, but definite proof is lacking.

MEDICINAL TREATMENT INEFFECTIVE

There is no drug, chemical, or medicinal compound that has been proved to be effective in the prevention or cure of Bang's disease. Much effort has been spent by various laboratories and experiment stations in the hope of finding some substance which could penetrate the tissues invaded by the *Brucella* organisms in a concentration sufficient to destroy the organisms without harmful effect on the tissues themselves. A number of different chemicals and compounds which have proved effective in various other diseases were tried in brucellosis, but none proved successful. Recently sulfanilamide, a chemical substance which has proved to be very effective in the treatment of streptococcic infections and which has been reported as beneficial in the treatment of brucellosis in man, was tried in cattle with *Brucella* infection of the udder. However, with a concentration in the blood of only slightly under toxic quantities, the drug had no apparent action in destroying the *Brucella* organisms or reducing their virulence.

Medicinal substances for the treatment of this disease have gained their popularity almost if not entirely because they were used and their value was judged at a time when the disease had passed its active stage; that is, when the wave of abortions had ceased. If a medicine is used after a cow has aborted a person is likely to give credit to the medicine when the animal fails to abort on her next pregnancy, whereas this cessation of abortion was a natural sequence in the disease.

Several widely advertised "cures" or "remedies," for which numerous testimonials were submitted, have been tested under controlled conditions and have been found worthless in the prevention or cure of brucellosis of cattle.

Following abortion or full-term pregnancy in the infected animal, a more or less heavy, persistent discharge from the uterus occurs. Nature may be assisted in relieving this condition by douching the uterus with mild, nonirritating antiseptics or preferably with a solution of common table salt in water in the proportion of one ounce of salt to a gallon of water. When douchings are made, boiled water cooled to body temperature with the salt added should be used and all utensils should also be boiled both before and after being used. Care should be taken that the washings from the uterus and the vagina are not expelled in a place to which cattle have access.

Following abortion or full-term pregnancy in an infected animal it may be some time before the inflammation in the walls of the uterus subsides and it is therefore very advisable to allow a period of several months' rest before the animal is bred again.

TREATMENT OF RETAINED AFTERBIRTH

Retention of the afterbirth is a common condition in herds where brucellosis of cattle prevails. Since the afterbirth of healthy animals often is not expelled until a few hours after delivery of the fetus or live calf, owners are justified in viewing its retention with little alarm until 24 hours after the act of abortion or parturition, provided the animal appears to be normal otherwise. Retention of the afterbirth longer than 24 hours signifies that inflammation of the uterus may be present and responsible for its adherence. When the afterbirth has been retained for 2 or 3 days, its putrefaction usually becomes marked. In this putrefactive process within the uterus, poisonous substances may be generated and absorbed by the animal causing fever, loss of appetite and other evidences of severe trouble. Severe cases may terminate fatally.

The afterbirth should be removed, before putrefaction becomes excessive, by reaching into the uterus with the hand and separating as carefully as possible the attached areas and flushing the organ afterwards with mild antiseptic solutions or warm salt water. A 0.5-percent Lugol's solution [2] is often used for this purpose. Boiled water which has been permitted to cool to body temperature and to every gallon of which 1 heaping tablespoonful of table salt has been added makes a satisfactory irrigating fluid.[3] The flushing may be done by the use of a soft-rubber tube, with a diameter of about one-half inch, to which a funnel is attached. The fluid should not be allowed to remain long in the uterus, but should be siphoned out by lowering the external end of the tube when filled with the fluid. As previously mentioned, care should be taken that washings are not expelled in a place to which cattle have access.

This description of treatment for retained afterbirth is given for the benefit of those who are unable to obtain the services of a veterinarian, who should preferably handle such cases. Treatment of this nature, if done without proper sanitary precautions, may result in permanent injury to the genital organs of the cow. Furthermore, the removal of an infected afterbirth by hand is dangerous to the operator since virulent *Brucella* organisms are present in vast numbers if the animal is affected with brucellosis. These germs may gain entrance to his body through abrasions in the skin of the arm and thus may cause brucellosis in the person doing the work.

STERILITY

Sterility or failure to get with calf may be the result of various conditions. Chief among these are the incomplete development of the female generative organs, diseased conditions of the ovaries,

[2] Lugol's solution of iodine is compounded as follows: Iodine, 5 parts; potassium iodide, 10 parts; and boiled water to make 100 parts. One part of this compound to 200 parts of boiled water makes a solution suitable for uterine irrigation. Lugol's solution may be purchased from any druggist.

[3] A 1-percent solution of common salt in boiled water at body temperature makes a suitable irrigating fluid. A heaping tablespoonful of dry salt weighs approximately 1 ounce, and this quantity in 1 gallon gives the proper strength.

sexual weakness of the bull, and chronic inflammation of the uterus following abortion due to brucellosis.

A normal function of the ovaries is to expel an ovum or egg, which is associated with the period of heat. In certain abnormal conditions of the ovaries, this function is lost and the affected animal fails to come in heat; in other ovarian conditions, the animal may be sterile but have continuous periods of heat, a condition known as nymphomania.

Failure of cows and heifers to conceive is sometimes due to their being mated with bulls which are weak sexually. Bulls differ markedly in their ability to produce pregnancy, especially if they are mated frequently. There are also other conditions in mating which make it advisable to try other bulls before considering a cow permanently sterile.

It is frequently observed in herds of cattle affected with brucellosis that a cow which has aborted may have to be served three or four times before she conceives. The cause of this is the inflamed condition of the uterus. Following abortion, the uterus is greatly thickened and inflamed, portions of the afterbirth may be still adherent to the cotyledons, or buttons, and there is almost invariably a thick brownish discharge flowing outward from the uterus. The afterbirth may be retained for several days before being forcibly removed, which adds further injury to the already inflamed uterus. Bacteria other than *Brucella abortus* may also gain a foothold and the inflammation may be so severe as to cause permanent sterility. Generally, however, the discharge ceases by the third or fourth week, but it may be several months before the uterus regains its normal condition and the *Brucella* organisms disappear from the organ. In the normal uterus at the time of estrum, or heat, a thin clear fluid is secreted through which the male sperm cells swim toward the female egg, or ovum. When the uterus is inflamed, the discharge which accompanies inflammation is so thick that it impedes the movement of the male sperms and when putrefactive substances are present due to other bacteria, the male sperms may be destroyed. It should be apparent, therefore, that aborting cows should be given a rest of at least 3 months before being bred, to allow the uterus to return to a normal condition.

Every long-standing case of sterility is a study in itself and should be entrusted to the care of a veterinarian if the value of the animal warrants such a procedure. Appropriate treatment in individual cases can be determined only after a careful examination of the generative organs. Although it is not always possible to eliminate diseased conditions when they have been found, professional advice on the outlook for recovery is frequently of value to the owner because it enables him to dispose of hopelessly sterile animals promptly.

CONTROL AND ERADICATION

Brucellosis of cattle may be controlled in a number of ways. Each method requires a thorough knowledge of the nature of the disease, together with continued watchfulness and patience. In many of the States, a Federal-State cooperative program of eradication is in progress which is based on the immediate removal of all reacting animals. Indemnities are paid the owner for all animals removed in States where funds are made available. This method in most in-

stances offers a most advantageous means for controlling the disease quickly and with little cost to the owner. Stockmen who derive their profit through the sale of cattle obviously must choose a method which will eradicate the disease from the herd as quickly as possible since most of the States now have regulations prohibiting the importation of reacting animals. This also applies to dairymen who sell milk in sections where regulations demand that the milk be produced by cows free from brucellosis. On the other hand, in purebred herds where valuable blood lines may be lost through slaughter or in herds in which such a large percentage of animals react to the agglutination test that the owner cannot afford to slaughter, other methods of control may be used advantageously.

In herds in which the disease is in an active state, that is, where a wave of abortions is occurring resulting from a primary infection, it is very difficult to control the disease since the premises are so heavily contaminated. In such case one of the other methods may be applied.

The four methods of control which have been used successfully are the following:

Test-and-slaughter method.
Calfhood vaccination with a culture of reduced virulence.
Sanitary control method or herd management.
Test-and-segregation method.

TEST-AND-SLAUGHTER METHOD

Obviously the surest method of eradicating any disease spread through contact is by the removal and slaughter of the infected animals. This method has proved very satisfactory in the control of bovine tuberculosis and has been very effective in reducing the incidence of Bang's disease under the Federal-State cooperative program, begun in 1934. Thousands of herds have been freed of this malady, after from one to six blood tests made at proper intervals, by the removal of the positive reactors, accompanied with disinfection of premises and other sanitary measures.

Even when allowance is made for Federal and State indemnity payments, this method of control might appear costly to the owner, especially where a large percentage of animals are affected, but the benefits are immediately available in calf production, a marked decrease in breeding troubles, and an increased milk supply.

The test-and-slaughter method has been criticized because not all herds may be cleaned up as a result of a few tests. Undoubtedly some of the poor results obtained in this respect have been due to too infrequent testing in herds in which the disease is in an active state. In such herds, greater success has been obtained when retests are made not more than 2 to 3 weeks apart. The test-and-slaughter method is more likely to prove successful and practical in herds in which the disease exists in a chronic form.

It has been found in some instances after the reactors are removed and replacements added to the herd that the disease may reappear in the replacements. Since replacements in these herds are invariably tested before shipment or purchased from negative herds, subsequent abortion in these animals indicates that there is a residual infection in the herd or that infection persists elsewhere on the premises. After a herd has been freed from infection, it is a virgin herd so far as reinfection is concerned and great care should be exercised in the matter of additions to the herd.

In several States the area plan of testing is in progress. This plan requires that all the cattle in a county be included in the Federal-State program. The area plan makes the test-and-slaughter method more effective in the eradication of brucellosis due to the lessening of possibility of reinfection in the area.

VACCINATION

Vaccination against brucellosis has been the subject of investigation for many years in various parts of the world. Killed *Brucella* organisms, those of reduced virulence, and even virulent cultures have been used with varying degrees of success in animals of all ages, pregnant and nonpregnant. The results as a whole show that an increased resistance is produced in most instances by most of the vaccines used, but under some conditions and with certain vaccines, the results were more harmful than beneficial. Consequently, many States have regulations governing the use of vaccines of any description within their borders. It was not until Buck [4] discovered a *Brucella* organism of reduced virulence, "strain 19," and vaccination was confined to calves between 4 and 8 months of age that a semblance of consistent results was established. Cotton and Buck [5 6] and their co-workers have made repeated experiments in which calves were vaccinated with strain 19 and subsequently exposed during the third or fourth month of their first pregnancy, with an equal number of control animals, to a virulent culture of *Br. abortus*.

Of 70 animals vaccinated during calfhood and exposed artificially to *Brucella abortus* during pregnancy, 1 aborted a dead fetus, 2 produced weak calves, and 63 produced normal calves. Four other animals aborted from causes other than brucellosis as *Br. abortus* was not recovered from the aborted fetus, or the afterbirth or the colostrum of the dam. Of 73 control animals exposed in the same manner, 51 aborted dead fetuses, 4 produced weak calves, and 18 produced normal calves.

Following parturition in the 70 vaccinated animals, *Brucella abortus* was recovered from the 3 that aborted and from 5 that produced normal calves. Of the 73 controls, *Br. abortus* was recovered after parturition from the 55 animals that aborted and from 2 that produced normal calves.

Briefly, 4.3 percent of the vaccinated animals aborted as a result of *Brucella* infection and 11.4 percent became infected following severe artificial exposure, whereas 75.3 percent of the unvaccinated (control) animals aborted and 78.1 percent of them became infected.

To determine the effectiveness of this method under natural conditions, field trials of calfhood vaccination in 260 badly infected herds in 24 States have been in progress since 1936. No control animals were used but the infected animals were allowed to remain in the herds to provide exposure.

A recapitulation of the figures covering the vaccinated animals involved in one, two, or three pregnancies during the first 4½ years is as follows:

A total of 8,182 animals were involved in the three pregnancies, of

[4] BUCK, J. M. STUDIES OF VACCINATION DURING CALFHOOD TO PREVENT BOVINE INFECTIOUS ABORTION. Jour. Agr. Res. 41: 667–689. 1930.

[5] COTTON, W. E., BUCK, J. M., and SMITH, H. E. FURTHER STUDIES OF VACCINATION DURING CALFHOOD TO PREVENT BANG'S DISEASE. Amer. Vet. Med. Assoc. Jour. 85: 389–397. 1934.

[6] BUCK, J. M., COTTON, W. E., and SMITH, H. E. VACCINATION OF CALVES AND YEARLINGS AGAINST BANG'S DISEASE. U. S. Dept. Agr. Tech. Bul. 658, 7 pp. 1938.

which 7,872, or 96.2 percent, calved normally, and 310, or 3.8 percent, aborted. Of the 310 aborting animals, 182, or 58.7 percent, were negative and 128, or 41.3 percent, revealed either a positive or a suspicious titer. Consequently, on a basis of the blood-agglutination test, only 128 abortions, or 1.6 percent of this group of 8,182 animals that were involved in the three pregnancies, could be attributed to brucellosis. Of the 1,346 animals that calved normally and revealed a positive or suspicious titer, approximately 500, or 37.1 percent, gave a negative reaction to the first retest applied 6 months later. In the first group of 97 animals that calved normally during the first pregnancy and disclosed a suspicious or positive titer, the fifth retest, applied 2½ years later, indicates that 75, or 77.3 percent of these animals, had returned to a negative titer.

The results from both the experimental and field trials of calfhood vaccination with strain 19 *Brucella abortus* showed that this method is very effective so far as calf production is concerned and markedly effective in actually preventing infection.

Accordingly, a plan for the official recognition of vaccination of calves as an aid in cooperative Bang's disease control was presented by the Chief of the Bureau of Animal Industry in December 1940. According to the provisions of the plan, calfhood vaccination, as well as the present test-and-slaughter method of eradication, may be used in States where the proper officials deem conditions favorable, contingent on acceptance of the plan by the proper authorities in such States.

One objectionable feature to vaccination against brucellosis in cattle lies in the fact that, soon after the injection of the vaccine, the blood titer, as indicated by the agglutination test, rises to a degree that cannot be differentiated from actual infection. Data collected on a large number of animals in this connection show that the older the animal, the longer the vaccinal reaction persists. In calves between 4 and 8 months of age, the blood titer usually returns to negative or not more than 1 to 25 within 4 to 8 months. Only rarely does an animal vaccinated during calfhood retain a positive titer at the time of first breeding. In older animals, the condition is different. A vaccinal titer as high as 1 to 100 may persist in these animals for a year or longer. The fact that the vaccinal titer persists in older animals for such a long period and cannot be differentiated from actual infection renders such a procedure undesirable if the removal of the actually infected animals by means of the blood test is desired. Pregnant animals should not be vaccinated with strain 19, since abortion has resulted in several instances following its experimental use in such animals.

Vaccination is also opposed by some persons because of the fear that complete virulence may be returned to strain 19 as the result of its abode in the vaccinated animal. Many thousands of calves have been vaccinated with strain 19 and no evidence has so far been presented to show that its virulence has increased in this manner. Vaccinated calves have been placed with normal pregnant animals without causing the latter to react in any degree to the agglutination test or become affected with the disease. Strain 19 has been injected into a normal pregnant cow in such large numbers as to cause abortion. The organism was recovered from the aborting cow, cultured, and again injected in large numbers into another pregnant animal, causing abor-

tion. The organism from the second cow was recovered and on comparison with the original strain it was found that no variation in its virulence had taken place. As a result of this and other similar work, it is believed that strain 19 may be used safely for vaccinal purposes under the conditions indicated.

Many States have regulations prohibiting or regulating the use of vaccine in controlling brucellosis of cattle. Persons interested in vaccination, therefore, should consult their State veterinarian or State livestock sanitary officials before having this product used in their herds.

The aim in the use of vaccine in a brucellosis-infected herd should be directed toward the eradication of the disease rather than merely toward the assurance of a calf crop. The eradication of the disease is possible only through the removal of the animals that continue to show agglutination reaction on repeated tests. The reacting animals may be removed immediately, if necessary, or gradually as vaccinated replacements become available. It should be obvious, therefore, that two requisites are necessary in this connection, first, that vaccination should be confined to calves between 4 and 8 months of age, and, second, that periodic blood tests should be made of the entire herd. To obtain the desired results, the administration of the vaccine and subsequent care of the affected herd should be entrusted to a qualified veterinarian.

SANITARY CONTROL OR HERD MANAGEMENT

In the discussions which have arisen concerning the merits and demerits of the test-and-slaughter method and vaccination in the control of brucellosis, another extremely valuable and effective method is sometimes overlooked. This plan, which is both practical and economical, is the sanitary control method, with special relation to herd management.

As previously stated, brucellosis in cattle undoubtedly would not exist if it were not for the fact that the uterus and the placental tissues of the pregnant dam offer mediums in which the *Brucella abortus* organisms can grow in large numbers. Therefore, if the infected animal could be separated from the remainder of the herd before parturition and kept segregated until all uterine discharge has ceased after calving, the means by which the disease is perpetuated would be removed. This method entails two requirements: First, a maternity barn, shed, or stall sufficiently removed to prevent direct exposure; and, second, a close, daily observation of each pregnant animal, especially first-term heifers.

When a pregnant heifer becomes infected, the impending signs of abortion are premature bagging, or swelling of the udder, swelling and inflammation of, and sometimes discharge from, the external genitals. In milking cows only the latter symptoms will be noticeable. When such signs are first noticed, the animal should be removed immediately to the maternity barn and kept from the remainder of the herd until abortion, or calving, has occurred and discharge has ceased.

The maternity barn naturally will be contaminated with the *Brucella* organisms and care should be taken that no infective material is carried from the barn by persons caring for these animals. Implements for feeding and watering should not be used anywhere else.

When leaving the premises the caretakers should wash their hands thoroughly with soap and water, and wash the soles of the shoes or boots thoroughly with a 3 percent cresylic disinfectant which should be kept at the exit of the building. Merely dipping the shoes in this disinfectant does not kill the organisms in lumps of manure attached to the shoes. The aborted fetus and afterbirth should be burned or buried in quicklime. When an aborting animal has recovered and the uterine discharge has ceased, the legs and hind parts should be washed with a 2 percent cresylic disinfectant before the animal leaves its quarters. It is best to place the cow in a pasture by herself for a few days, after which she may be placed with the remainder of the herd. As a safeguard, such animals should not be bred for at least 3 months after calving or aborting. This practice, while involving extra work, pays splendid dividends and the disease in many herds has been controlled through this method.

These sanitary control measures, when used in conjunction with the test-and-slaughter method or vaccination, greatly increase their efficiency through the removal of exposure. The fact that brucellosis may be controlled by sanitary means allows the formation of a cardinal rule in this connection, namely: Do not allow any animal to abort or calve in the pasture or barn in contact with normal animals in the herd. At the first indication of approaching parturition, the animal should be placed in a maternity stall.

TEST-AND-SEGREGATION METHOD

This method consists in segregating the reactors to the blood agglutination test in an infected herd apart from the nonreactors. Separate premises are necessary for each group. Extreme care must be taken to prevent direct or indirect contact between the two divisions. Retests at frequent intervals are made of the nonreacting group in order that incipient infection may be detected and the reacting animal removed. Many valuable herds have been freed from infection by this method, but it is not a desirable one for several reasons: (1) Only a few owners can provide facilities for two herds; (2), it is usually a long drawn-out procedure before the reacting herd can be disposed of; and (3) the possibility of a single act of negligence in the care of the nonreacting herd may result in the loss of several years' effort.

PREVENTION

With brucellosis so widespread as it is at the present time, the owner of a herd of cattle free from this disease must be continually on guard to prevent infection gaining entrance to his herd. To do this intelligently, the various methods by which infection is spread must be understood.

Undoubtedly, the chief manner in which this disease is introduced into a herd is through replacements or additions, especially of pregnant heifers or pregnant cows. All additions to a herd should be negative to the agglutination test or purchased from herds accredited as being free from brucellosis. Even though negative to the test at time of purchase, it is advisable to keep all additions from direct contact with the herd for a period of 3 months. Another negative test after that period indicates that they may be placed in the herd with a reasonable degree of safety. Calves suckling dams with udder in-

fection may carry virulent *Brucella* organisms in the digestive tract for a few days to possibly a few weeks following separation from their dam and, therefore, should not be placed with susceptible cows for at least a month. Animals shipped by train, especially if unloaded in yards for watering, should be kept segregated for several months and retested before being placed in the herd. Animals shown at fairs and livestock shows may incur exposure to infection and it is advisable, therefore, to test them 2 or 3 months after their return. Naturally, any animal showing a suspicious or positive reaction should be removed immediately from the remainder of the herd.

Drainage from adjacent infected premises should be diverted, if possible. Likewise, small sluggish streams flowing through and from premises known to be infected should be fenced off. The danger of infection through streams is proportional indirectly to the size of the stream and its rate of flow, that is, the larger the stream and the faster it flows, the less danger there is. The pasturing of cattle near railroad yards where there may be contaminated bedding or manure from stock cars should be avoided.

The practice of taking a cow to a neighbor's premises for service presents a hazard. Such service should preferably take place on neutral ground.

Unpasteurized milk from creameries or other sources may readily carry *Brucella* germs to the farms where the milk is used. The pasteurization of this milk, that is, heating it to 145° F. or higher for 30 minutes will make it a safe article for feeding. Unfortunately, pasteurization is not always properly carried out. The pasteurizing equipment may be inadequate or out of order. The milk may not be heated to the proper temperature for a sufficient length of time. Instances have been noted in which the pasteurized milk was replaced in the original containers, without the latter being cleaned and sterilized. Such defects in the process of pasteurization defeat its purpose.

Stockmen should realize that there is an element of danger in visiting farms where infectious diseases exist. Disease germs may be brought home on shoes or clothing. The possibility of carrying infection in this manner, although remote, should be recognized. The old adage, "An ounce of prevention is worth a pound of cure," is sound advice in regard to brucellosis and no possibility of preventing infection from gaining entrance to a normal herd should be overlooked.

BRUCELLOSIS IN SWINE

Brucellosis of swine, or infectious abortion of swine, is caused by a species of *Brucella* organism known as *Br. suis*. The disease in swine is very similar to the disease in cattle in that it often causes abortion in the pregnant sow and may localize in the mammary gland. The disease may lodge also in the genital organs of the boar. Abortions do not occur so often in sows as in cows probably because the period of gestation in sows in only 4 months. Following infection, the *Br. suis* organism may be present in the blood stream for about 30 days. Recovery from the disease occurs more often in swine than in cattle, but the disease may persist indefinitely unless affected animals are removed from the premises. The test-and-slaughter method is now the most effective means by which the disease may be controlled. Diagnosis is made by the blood agglutination test or by the recovery of

the infecting organism from the aborted fetuses, fetal membranes, uterus, or milk.

BRUCELLOSIS IN GOATS

Brucellosis in goats is caused by a third species of *Brucella* organism, *Br. melitensis*. The disease in goats is very similar to the disease in cattle and swine, and the methods of diagnosis and control are the same as those described for cattle and swine. The disease in goats has been reported in the southwestern portions of the United States and sporadically in other portions. It is very prevalent in southern Europe. It is accepted by authorities that *Br. melitensis* is the most virulent for man of the three species of *Brucella*, and it is therefore very essential from a standpoint of public health that the owners of goats producing milk for human consumption have their flocks tested for brucellosis as the germs are very commonly found in the milk of affected does.

BRUCELLOSIS IN MAN

Aside from its economic effect on the livestock industry, brucellosis in animals is a menace to human health. It has been proved by investigators of the Public Health Service, of the Federal Security Agency, that all three species of *Brucella* organisms, *Br. abortus*, *Br. suis*, and *Br. melitensis* may cause brucellosis in man under favorable conditions.

The disease in man may be contracted by drinking the unpasteurized milk of cattle or goats having udder infection. It may also be contracted by veterinarians and stock owners in the removal of the retained placenta of aborting animals, by abattoir workers through the handling of carcasses of affected cattle, swine, or goats, or by laboratory workers in culturing the organisms. Butter prepared from unpasteurized sweet cream has been shown to contain virulent *Brucella* organisms for 8 weeks after preparation, but in butter prepared from sour cream the organism was not recovered after one week. Unpasteurized, sweet-cream butter may, therefore, be another source of infection for man.

The disease in man is similar whether caused by any one of the three species of *Brucella* organisms. Common symptoms, as reported by the United States Public Health Service, are as follows: At the onset, the disease may be confused with grippe or various other diseases and may be characterized by fever, headache, aches in various joints, especially in the extremities, fatigue, chills followed by a further rise in temperature, and profuse sweating. With the continuation of the disease, there may be progressive weakness, recurrent regional pains, loss of appetite, constipation, and sleeplessness. The symptoms may disappear for a few days, followed by a recurrence, hence the name "undulant fever," as the disease is sometimes called; or the symptoms may continue without alteration. Very frequently in the chronic form of the disease in man, symptoms of the nervous system are present, such as depression or irritability, and symptoms suggestive of neurasthenia.

Further information relative to brucellosis in man may be obtained from the Public Health Service, Federal Security Agency, Washington, D. C.

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